Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE

AMERICAN NATURALIST

VOL. XXVI. February, 1892. 302

PHENOMENA AND DEVELOPMENT OF FECUNDATION.[1]

BY H. J. WEBBER.

NECESSITY OF REPRODUCTION.

The necessity for animals and plants to have some means of reproducing themselves is clearly evident. Every organism has what we may term a normal length of life, which as Weismann has shown, is probably determined by the environment of the species, having been gradually developed by natural selection. If then, after a certain period, organisms die, species would become extinct unless means are provided for their perpetuation.

Of certain organisms, however, we cannot predicate that death will occur. On the contrary, for the Protozoa and probably Protophyta, (unicellular organisms,) it has been determined by investigation that there is no normal length of life and consequently following, death. They are according to Weismann, immortal, so far as normal death is concerned. Nevertheless here also is a necessity for reproduction. Accidental death must be considered and the ravages from higher animals to which the Protozoa and Protophyta are exposed, are enormous. So throughout animals and plants, without exception, methods are provided for the reproduction of the species.

---

[1] A lecture delivered December 16, 1891, before a meeting of the Alumni Association of the St. Louis Medical College.

The first and simplest reproduction is a simple, almost mechanical fission or breaking apart of a naked mass of protoplasm, which is nevertheless an organized being, as seen in the fission of the swarm spores of Myxomycetes, in other Protozoa and Protophyta. The body of the organism, after a lengthened period of growth, reaches a size where the proportion of the surface to the bulk is not sufficient to provide suitable nourishment for its continued growth. Thus a division or multiplication of the body is necessitated to provide greater surface for absorption.

In a thorough consideration of these facts, we come to see how intimately growth and reproduction are associated, growth being nothing more than a protoplasmic and usually cellular reproduction. We are very apt to think of cell division as a necessary accompaniment of growth. But this is not so. Growth is independent of cell multiplication. Cell division need not take place during growth, but may appear only after its conclusion. In *Stypocaulon*, an alga belonging to the Phæosporeæ the lateral branches of the frond, as pointed out by Geyler, attain their full size before the formation of cells begins. Cells are then formed from the base upward, until finally the branch, which was a single cell, becomes a normal multicellular organ. One of the most remarkable cases illustrating this point is found in Caulerpa, a seaweed, the whole vegetative body of which remains throughout life an enormous single cell. (Fig. 1, a portion of frond, natural size). In the cavity of this thick walled vescicle, however, numerous cross bars of cellulose are found to give greater strength. In the common green felt (Vaucheria) even these cross bars are wanting. Cell division, however, usually accompanies growth and as shown above is in most cases a necessity to provide sufficient nutrition.

CELL REPRODUCTION.

The phenomena of cell reproduction or division are so intimately connected with the consideration of all phenomena of reproduction and fecundation that it is necessary for us to briefly consider this subject as a preparatory step. The changes which take place in the cell nucleus seem to be of paramount importance in cell division. Since Robert Brown, in 1833, first discovered the cell nucleus in the generative organs of orchids, and Von Mohl in 1835 first saw it divide, it has been growing in importance until now, or at least not long ago, the majority of biologists were willing to assign to it all importance in reproduction and in the life of the cell, the cell brain as it were.

Amitosis.—We need only to consider the so called *indirect, mitotic* or *karyokinetic* division. The *direct* or *amitotic* nuclear division it appears from Flemming's[1] late paper and Ziegler's[2] biological discussion of *amitotic* nuclear division, having merely a nutritive or secretory function, occurs in the animal kingdom only at the end of typical cell multiplication, when the cell is given over to other purposes and loses its power of physiological multiplication and reproduction of cells. Amitotic nuclear division then always indicates the end of the series of divisions. Ziegler thinks "it occurs chiefly (perhaps exclusively) in such nuclei as minister to a process of unusually active secretion or assimilation." In typical gland cells it is frequently found. Whether like conclusion will be reached in the vegetable kingdom is yet doubtful, but in the absence of definite investigations we are justified in assuming that similar limitations may be drawn, and that in our consideration of reproduction we need not further discuss this kind of cell division.

Karyokenesis.—In the cell nucleus, two kinds of protoplasm may be distinguished, the *chromatin,* so named from its strong affinity for stains, and the achromatin. Other substances have, it is claimed, been differentiated, but these will for the present answer our purpose. Investigators have come almost uniformly to agree that the essential features of karyokenesis lies in the equal distribution of the chromatin elements to the daughter cells.

The resting nucleus (fig. 2) presents under the microscope a finely punctate character but close examination will show us that these granules (*microsomata*) are connected by fine granu-

---

[1] W. Flemming, "Ueber Teilung und Kernformen bei Leukocyten und über deren Attraktionssphären." Archiv. f. mikr. Anatomie, 37Bd. 1891.

[2] H. E. Ziegler, "Die biologische Bedeutung der amitotischen (direct) Kernteilung im Tierreich." Biol. Centralblatt, Bd. XI, pp. 372-389, July 1891.

lar threads, and that these, winding up and down here and there in the nucleus, form the so-called reticulum of the nuclear protoplasm. It is in reality then a complexly coiled, possibly continuous thread composing the chromatin matter of the nucleus, coiled in the clear achromatin and surrounded by the nuclear membrane. The first indication of division is an increase in the size of the nucleus. The reticulum gradually contracts until the nucleus, presents a coarsly granular appearance. This contracting continues. The protoplasm begins to collect at the ends of the nucleus which will be the poles of the future nuclear spindle. The contracted chromatin thread becomes apparently homogeneous and finally breaks up into an even number of segments which are distributed in a more or less definite manner at the equator of the nuclear spindle which has made its appearance in the protoplasm during the above changes (figs. 3–4). Each segment now divides into two, splitting longitudinally, making twice the original number, and these, yielding to an apparent attraction from the poles of the dividing nucleus, gradually separate in a definite manner and pull away from the equator toward the poles, following the lines of the delicate nuclear spindle. As they approach their respective poles the daughter segments draw closer and closer together until their upper ends meet and fuse (figs. 5–6). The lower ends then bend inward and also apparently fuse forming a continuous coil (figs. 6–7); while the daughter segments move towards the poles, the spindle fibres remain behind, and others become intercalated and a bulging out occurs, forming ultimately a barrel shaped structure. Soon in the equatorial region slight thickenings form on the spindle fibers (figs. 7–8). These become more and more marked and gradually touch and fuse, forming the new cell-wall between the now divided daughter nuclei (fig. 9).

During the process of cell-wall formation, the segments of the daughter nuclei which have united as above explained, begin to elongate and decrease in thickness, taking on the appearance of the resting nucleus. The remaining steps are just the reverse of those preparatory to division. The filament elongates and decreases in thickness until it comes again to present the appearance of a resting nucleus.

The above outline of the general course of cell division, in main taken from Strasburger, represents the view of cell division in the vegetable kingdom that has been recognized until very lately.

Karyokinesis in the Animal Cell.—In the division of the animal cell, the phenomena agree in all essential features. We have appearing here the two important bodies occupying the poles of the dividing nucleus, designated first by Fol as *"asters"* later by Van Beneden as *"attractive spheres"* and quite recently by Boveri as *"archoplasmic spheres."*

The central area of the archoplasm (fig. 10, a.) is situated in the cytoplasm near the nuclear membrane, and from it, as a centre there radiate out in all directions the granular archoplasmic filaments or radiating striae of the asters, some directed toward the nucleus and penetrating into it. The center of the archoplasm is sometimes occupied by a definite body the so-called *centrosome.* The fundamental importance of the function of the archoplasm and its centrosome is yet rather doubtful. Van Beneden looks upon it as a permanent organ, equal in value to the nucleus itself. Guignard, as we shall shortly see, is inclined to assign to it paramount importance in cell division, as directing and guiding the distribution of the chromatin elements.

When we examine a daughter nucleus at the close of karyokinetic division, we see at one side of it the archoplasmic sphere in the position it occupied during the process of division. Shortly before a new division starts (or we may say as the first step in the next division) this archoplasmic sphere divides into two (fig. 11) and the two new archoplasmic spheres thus formed, pass around the nucleus in opposite directions until they come to occupy points on exactly opposite sides, when their effect is soon shown by the starting of the phenomenal changes of karyokinetic division. Thus it is seen as new nuclei arise by division, so also the new archoplasmic spheres arise in in the same manner.

Guignard's[1] *and Wildeman's*[2] *Recent Discoveries.*—It is not until very recently that anything similar to the asters or archoplasm has been discovered in the vegetable cell. This year Guignard, a careful observer, published his observations "On the Existence of Attractive Spheres in the Vegetable Cell" which, from present appearances, marks an epoch in the development of vegetable cytology.

In the resting nucleus, according to Guignard, two *attractive spheres* or *asters* are present. They lie close together at one side of the nucleus, (figs. 49, 54 and 56). Within each is a central corpuscle, the centrosome (figs. 12, a, 49, 54, etc.) surrounded by a transparent areole and around this a granular circle (fig. 12 b.). In general the radiating striae are invisible as long as the cell is in a state of repose (fig. 49). They become feebly apparent when the nucleus presents the first symptoms of entering upon division and at this time they withdraw from each other in order to place themselves at two opposite points corresponding to the poles of the future spindle (figs. 12 and 51). After this the striæ become more evident and direct themselves toward the nucleus, while it is still provided with a nuclear membrane, which confirms the opinion of Strasburger that the spindle originates outside the nucleus in the cytoplasm. When the chromatin segments have separated and collected at the poles, the centrosomes divide in each sphere into two new centrosomes, which thus have their origin at each pole (figs. 53 and 55). They remain in this position till the next nuclear division is preparing to start, when they separate as explained above.

"In resume," says Guignard, "the bodies in question, which merit the name of directive spheres since they govern the division of the nucleus, transmit themselves without discontinuity from one cell to the other throughout the life of the plant."

---

[1] Leon Guignard, "Sur l'Existence des 'Spheres Attractives' dans les Cellules Vegetales." Compt. Rend. Soc. de Biol. T.iii; p. 182. (March 20, 1891).—Ann. des Sci. Nat. Bot. T. xiv; No's. 3-4; pp. 163-288 (Nov. 1891), (10 pl.). Comptes rendus Acad. des Sci., 9 Mars 1891.

[2] E. De Wildeman, in Bull. Acad. Roy. Sci. Belgique, LXI (1891) pp. 594-602 (1 pl.)

It is interesting to note that very shortly after the appearance of Guignard's paper on attractive spheres, Wildeman (l. c.) published a paper on the same subject containing observations on Spirogyra and several Liverworts and Mosses which is entirely confirmatory of Guignard's discoveries, and Van Tieghem[1] has proposed the term *"directing leucites"* or *tinoleucites* for them, from their property of inciting and directing the binary division of nuclei.

CHARACTER OF THE SEXES.

Geddes and Thompson's Katabolic-Anabolic Theory of Male and Female.—In approaching a consideration of fecundation it is well for us to inquire into the characters of the sexes and as to what determines sex. Let us plunge immediately into a discussion of the theory which seems to us to be the best yet suggested. Geddes and Thompson in their excellent work on the "Evolution of Sex"[2] strongly support what we may term the *katabolic-anabolic* theory of male and female.

In the changes of protoplasm necessitated by the process of living, the upbuilding constructive series of chemical changes are known under the general term *anabolism*; while the disruptive descending series are known under the term *katabolism.* Now male and female differ according to this theory of Geddes and Thompson in their physiological habits; the female being fundamentally of an anabolic character, the male of katabolic character. According to this view males are stronger, handsomer, more active, etc., merely because they are males, that is, are of more active physiological habit,—more metabolic—disruptive changes tending to predominate in the sum of changes in the living matter. The females, on the other hand, live at a profit, are more anabolic,—constructive process predominate in their life; whence indeed their capacity of bearing offspring.

Haeckel in the introduction to his "History of Creation" remarks that the intrinsic value of an hypothesis or theory, depends upon the number of phenomena we can explain by its application. Judging this theory of sex by such a standard, and we come to realize its great worth, reaching to the very boundaries of sex in its application and being a chief element in the development of sex. Of the very numerous illustrations given by Geddes and Thompson, we can only select a very few.

---

[1] Van Tieghem, Journ. de Bot. (Morot), V. (1891) pp. 101-102.

[2] Geddes and Thompson, "Evolution of Sex," London 1889.

The female cochineal insect, laden with reserve products spends most of her time on the cactus plant as a mere quiescent gall, while the male, on the contrary, is provided with wings, agile, restless and short lived. Almost innumerable instances of a similar character might be cited. Up to the level of the amphibians the females are generally larger. A sluggish conservative habit of body tends to an increase of size. Lavish expenditure of energy uses up the reverse material and keeps down the size. The large and small spores (macrospores and microspores) which we find in plants, and which mark the beginning of sex, illustrate the same law. Of sex cells in general, all are familiar with the fact that the antherozoids and spermatozoids are always much smaller and infinitely more active than the female cells. The agility of males it appears then is not a special adaptation as Darwin suggested to enable them to better and more surely perform their functions with relation to the other sex, but is a natural characteristic of the constitutional activity of males.

Body temperature which is an index to the pitch of life is distinctly lower in females as observed in the human species, insects and plants.

A familiar and striking illustration of this law is found in the process of menstruation, if it has been rightly interpreted. You are likely, as physicians, more familiar with the various theories of menstruation than I. Probably the most generally accepted one is "that which regards the growth of the mucus coat before fecundation as a preparation for the reception of an ovum if duly fertilized, and the menstruation process itself as the expression of the failure of these preparations." If we express it now in terms of the anabolic-katabolic law, or the anabolic highly vegetative character of the female, menstruation is the means of getting rid of the anabolic surplus in case it is not consumed as intended in the growth and development of the forming embryo. If fertilization be accomplished we should expect no menstrual flow and so indeed it is,—we have none; the, as it were, parasitic embryo using up the surplus. So also during lactation, while the offspring is still supported by the mother, menstruation does not usually occur, and here also from this theory of sex and of the anabolic female we should not expect it to occur, the surplus being taken up in the support of the offspring. At the close of lactation, menstruation begins again, as we should further expect.

A very different yet similar case is found in the secretion of nectar in flowers. The distinctive anabolic flow continues until fecundation is accomplished, after which it ceases and the surplus passes into the forming seed.

The katabolic-anabolic law seems also to have fundamental importance in determining the sex of a developing embryo. Some experiments conducted by Young, on tadpoles, are very interesting and instructive as bearing on this problem.

Tadpoles pass through a hermaphrodite stage, in common, according to other authors, with most animals. During this phase external influences and especially food decide their fate as regards sex, though hermaphroditism sometimes persists in adult life. When tadpoles were left to themselves, the percentage of females was rather in the majority, the average number being about 57 in a hundred. In the first brood, by feeding with beef, Young raised the percentage of females from 57 to 78: in the second with fish, the percentage raised from 61 to 81; while in the third set when the especially nutritious flesh of frogs was supplied, the percentage rose from 56 to 92. That is to say in the last case, the result of high feeding was that there were 92 females to 8 males. These results coming from such an investigator, emphasizing the anabolic character of the female, are surely very suggestive.

Meehan's observation that old branches of conifers overgrown and shaded by younger ones produce only male inflorescence; and those of various botanists that prothallia of ferns grown in unfavorable conditions produce only antheridia and no archegonia or female organs are further illustrations of the same law and its bearing on the determination of sex.

(*To be continued.*)